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TECHNICAL REPORT 2297

DEVELOPMENT OF AN IMPROVED EXPLOSIVE CHARGE FOR THE M1A1 BANGALORE TORPEDO AND THE M3 DEMOLITION SNAKE (U)

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JULY 1956

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PICATINNY ARSENAL
DOVER, N. J.

ORDNANCE PROJECT TA3-5306, ITEMS KK AND V
DEPT. OF THE ARMY PROJECT 5A07-02-0012

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Dept of the Army Project 5A07-02-0012

Approved:
Robert Frye
for D. R. BEEMAN
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OBJECT

To develop a new explosive loading for the M1A1 bangalore torpedo and M3 demolition snake which will improve the performance of these items and which will be less sensitive to rifle-bullet impact.

SUMMARY

The M1A1 bangalore torpedo and the M3 demolition snake have 80/20 amatol as the main charge and crystalline TNT as the end charges. Because of the sensitivity of crystalline TNT to rifle bullet fire, these demolition items are unsafe under combat conditions.

To improve the safety and performance of both the torpedo and snake, the following loadings were compared with the standard loading:

	Main Charge	End Charges
Filler 1	Composition B	Composition A-3
Filler 2	TNT (cast)	Composition A-3
Standard Filler	80/20 amatol	TNT (crystalline)

Filler 1 was less sensitive to rifle-bullet impact than the standard combination.

Although Composition A-3 was not affected in 150 bullet-impact tests using .30 caliber ball, .50 caliber ball, .50 caliber AP or .50 caliber APIT rounds, crystalline TNT detonated 47 times in 98 tests using .30 caliber or .50 caliber ball. Composition B, 80/20 amatol, and cast TNT were all essentially unaffected by rifle fire in 154 tests with .30 caliber or .50 caliber ball.

In functioning tests at ambient temperature and at −65°F, both filler 1 and the standard filler were reliably initiated by Type II special blasting caps inserted in the detonator. However, they could not be initiated by No. 60 detonating cord wrapped around one end of the torpedo.

Under similar test conditions the filler 1-loaded torpedo cleared 90% of the mines in an experimental mine field; the standard loaded torpedo cleared 75% of the mines. The filler 1-loaded demolition snake cleared 100% of the mines; the standard-loaded snake cleared 87.5% of the mines.

A torpedo loaded with filler 1 produced the largest crater, 24 cubic feet. Filler 2 produced a crater of 16 cubic feet, and the standard filler a crater of 12 cubic feet.

Although tests at Picatinny Arsenal showed that torpedoes loaded with filler 1 were somewhat superior in wire-cutting effectiveness, no appreciable difference in this respect was demonstrated in the tests conducted at Fort Knox.

Composition B or cast TNT is preferable to 80/20 amatol as the center charge of these items because amatol is more difficult to load and is hygroscopic. The only apparent disadvantage in the use of Composition A-3 is that it is

slightly more difficult to load than crystalline TNT.

CONCLUSION

The use of Composition B as the main charge and Composition A-3 as the end charges in both the bangalore torpedo and the demolition snake improves their performance and rifle-bullet safety.

RECOMMENDATIONS

Composition B and Composition A-3 should be used as the center charge and end charges, respectively, for the bangalore torpedo and demolition snake cartridge.

Cast TNT should be used as an alternative center charge for these demolition items.

The use of explosive pellets for the end charges of the torpedo should be investigated.

INTRODUCTION

1. Picatinny Arsenal was requested (Ref A) by the Office, Chief of Ordnance, to develop, for the M1A1 bangalore torpedo, an explosive charge which would be insensitive to rifle and machine gun fire. This new charge was to function reliably at temperatures ranging from -65°F to 125°F and was to give improved performance if possible.

2. In approaching this problem, it was assumed that the 80/20 amatol center charge of the M1A1 bangalore was relatively insensitive to bullet impact while the crystalline TNT end charges were sensitive to such impact. The basic problem, therefore, was to develop a replacement for the crystalline TNT. It was also apparent that because 80/20 amatol is difficult to load, is extremely hygroscopic, and has a low rate of detonation, a better center charge could probably be developed.

3. Composition A-3 and Composition B were selected for study as the end charges and center charge, respectively. In December 1953, however, OAC requested that cast TNT be approved as an alternate center charge for the torpedo because of the difficulty in loading 80/20 amatol (Ref B). Accordingly, the investigation was expanded to include tests of torpedoes loaded with a cast TNT center charge and a Composition A-3 end charge.

4. When the investigation of the M1A1 bangalore torpedo was begun, it was requested that the M3 demolition snake be included in the study (Ref C). Because the problem was almost identical for both items, the development tests were conducted only with the torpedoes. This report covers these tests and also includes the results of Army Field Force Board Tests of filler 1-loaded bangalore torpedoes (designated M1A2) and demolition snake cartridges (designated M3A1) both containing Composition B as the main charge and Composition A-3 as the end charges.

RESULTS

5. Bangalore torpedoes, with three different explosive loadings as shown below, were tested for sensitivity to rifle-bullet impact at −65°F, 160°F, and ambient temperature:

	Main Charge	End Charges
Filler 1	Composition B	Composition A-3
Filler 2	TNT (cast)	Composition A-3
Standard Filler	80/20 Amatol	TNT (crystalline)

The results, detailed in Table 1, are summarized below:

a. End Charges

(1) Composition A-3 gave no action in 55 tests with .30 caliber ball, 83 tests with .50 caliber ball, and 6 tests each with .50 caliber AP and .50 caliber APIT rounds.

(2) Crystalline TNT detonated in 13 of 45 tests with .30 caliber ball and in 34 of 53 tests with .50 caliber ball.

b. Center Charges

(1) Composition B gave no action in 22 tests with .30 caliber ball and in 38 tests with .50 caliber ball.

(2) Cast TNT gave no action in 10 tests with .30 caliber ball. In 26 tests of cast TNT with .50 caliber ball, no action was noted, except that smoke was observed in 3 of the 6 tests at −65°F.

(3) 80/20 amatol gave no action in 22 tests with .30 caliber ball. In 38 tests of this explosive with .50 caliber ball, no action was noted except that smoke was observed in 3 of the 6 tests at −65°F.

6. Sensitivity to initiation was determined by testing bangalore torpedoes with two types of end charges, Composition A-3 and crystalline TNT. The results, detailed in Table 2, were:

a. Blasting Caps: Twelve torpedoes with Composition A-3 end charges were tested at ambient temperature, 10 at −40°F, and 2 at −65°F. Seven torpedoes with crystalline TNT end charges were tested at ambient temperature only. With a Type II special blasting cap, all of the above torpedoes were unfailingly initiated.

b. No. 60 Detonating Cord: With No. 60 detonating cord wrapped around one end of the cartridge, 8 out of 10 torpedoes with Composition A-3 and 3 out of 5 with crystalline TNT end charges failed to initiate at ambient temperature. In 7 tests at −65°F using No. 60 detonating cord wrapped around Composition A-3 end charges and with the loose cord end inserted in the fuze well, 4 torpedoes failed to initiate.

c. No. 45 Detonating Cord: With No. 45 detonating cord wrapped around the end, 6 torpedoes, 3 each with

Composition A-3 and crystalline TNT end charges, all failed to initiate when tested at ambient temperature.

7. Barbed-wire-clearance tests were conducted at Picatinny Arsenal using a specially constructed frame with barbed wire strands (Fig 1). The appearance of the wires after firing is shown in Figure 2. Detailed results, given in Table 3 are summarized as follows:

a. Torpedoes loaded with filler 1 cut a total of 73 double strands of No. 12 gage barbed wire in 5 tests.

b. Torpedoes loaded with filler 2 cut a total of 68 double strands.

c. The standard torpedoes cut a total of 65 double strands of barbed wire.

8. Fort Knox Tests: Wire clearance tests were also conducted at Fort Knox. These tests showed no appreciable difference in barbed-wire-clearing effectiveness between torpedoes loaded with filler 1 and the standard loaded torpedoes (Ref F).

9. Crater Formation: In cratering tests conducted at Picatinny Arsenal, the torpedoes loaded with filler 1 formed a crater of approximately 24 cubic feet with a depth of 1 foot. The standard torpedo formed a crater of approximately 12 cubic feet with a depth of 8 inches, while the units loaded with filler 2 formed a crater of approximately 16 cubic feet with a depth of 8 inches (Table 3). Figures 3 and 4 give detailed dimensions of the craters formed at Fort Knox by torpedoes and snakes loaded with both the filler 1 and the standard filler combinations.

10. Mine Clearance: Mine clearance tests were conducted at Fort Knox with the torpedoes (Fig 5) and the snakes (Fig 6). The filler 1 charge was compared with the standard charge in both these items. Test results are given in detail in Table 4 and summarized as follows:

a. In dry soil, torpedoes loaded with filler 1 cleared 90% of all AP and AT mines over an 8-foot path width and 78.2% over a 14-foot path width; the standard torpedoes cleared 75% and 59.5%, respectively.

b. In wet soil, torpedoes loaded with filler 1 cleared 93.5% of all AP and AT mines over a 5-foot path width and 72.8% over 14 feet; the standard torpedoes cleared 56.3% and 53.2%, respectively.

c. In dry soil, snakes loaded with filler 1 cleared 100% of all AP and AT mines over a 55-foot path width and 90.5% over 70 feet; the standard snake cleared 87.5% and 81.5%, respectively.

d. In wet soil, snakes loaded with filler 1 cleared 100% of all AP and AT mines over a 25-foot path width and 90.5% over 60 feet; the standard snake cleared 84% and 74.5%, respectively.

11. Durability Tests: Durability tests were conducted at Fort Knox to determine

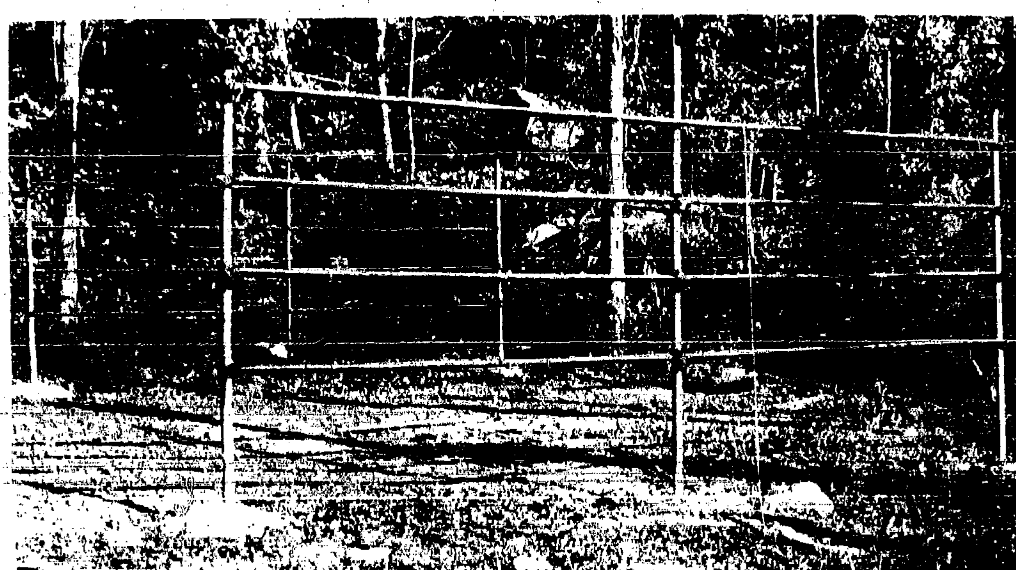


Fig 1 Structure for Barbed Wire Clearance Test at Picatinny Arsenal – Before Firing Bangalore Torpedo

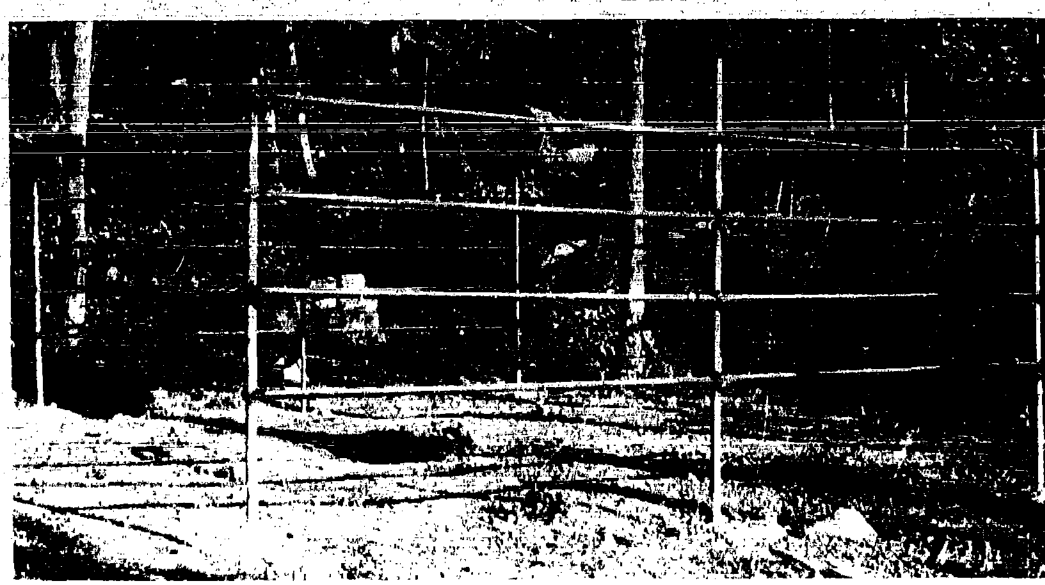


Fig 2 Appearance of Test Structure After Firing Bangalore Torpedo

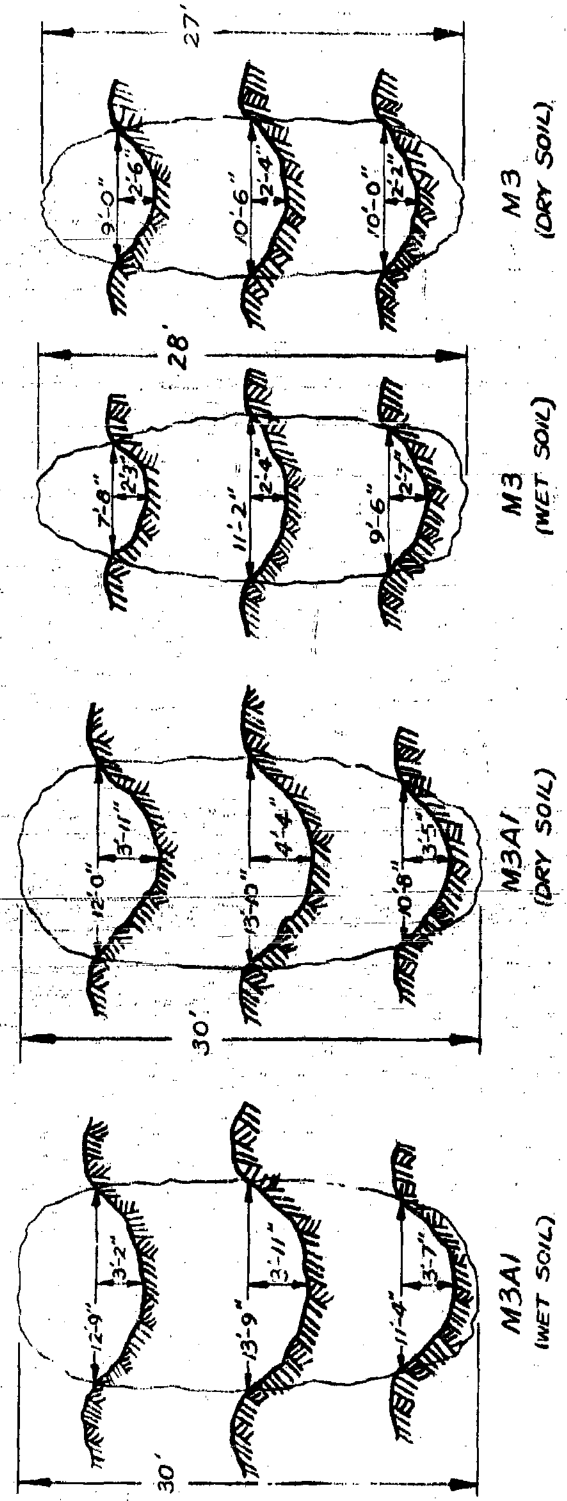


Fig 3 Cross Section of Blast Craters Made by Bangalore Torpedoes in Tests at Fort Knox, Ky. (Scale: 1" = 1 foot)

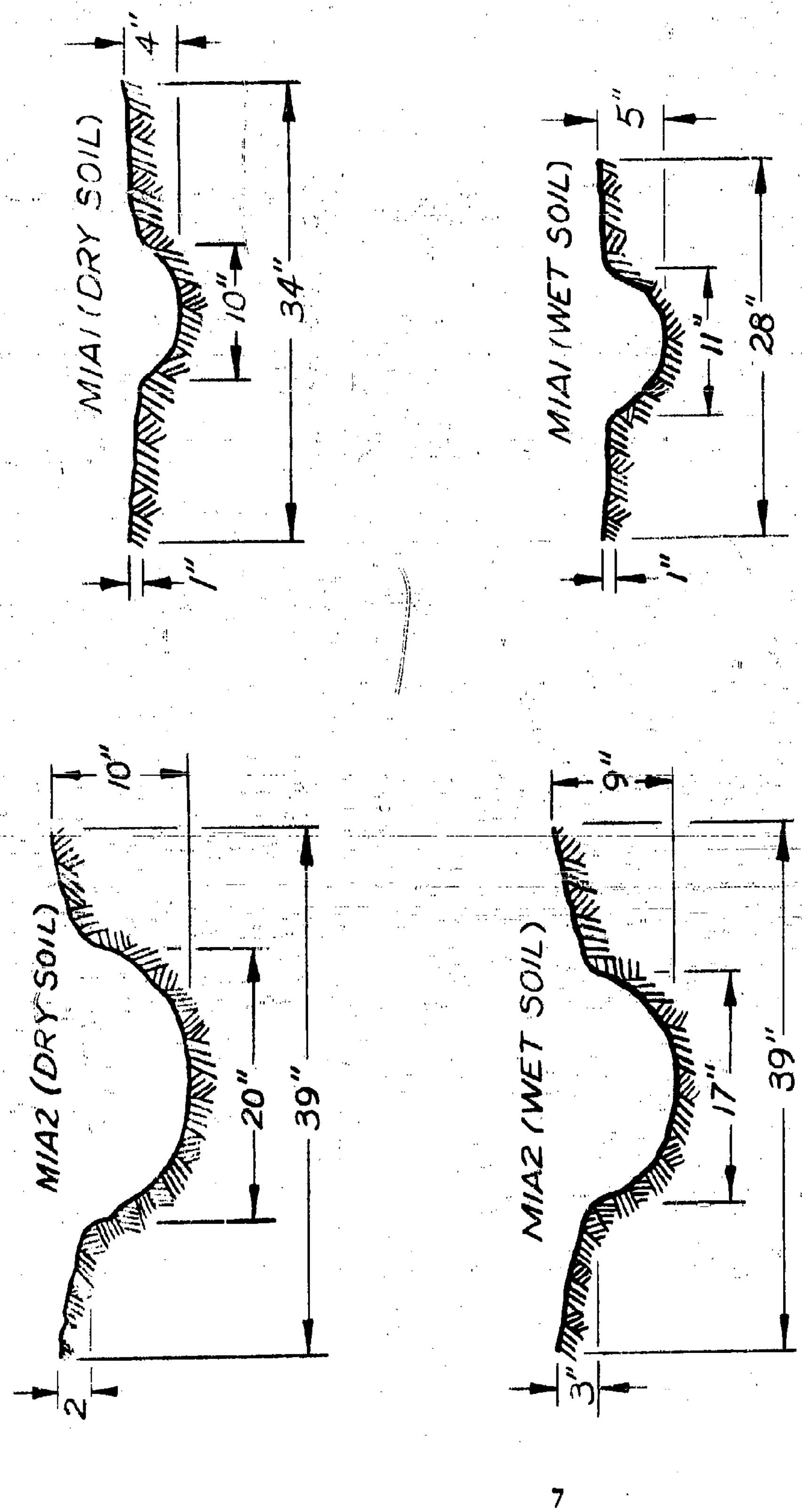


Fig 4 Blast Craters Produced by Demolition Snakes in Tests at Fort Knox, Ky. (Scale 1 inch = 10 feet)

Fig 5 Craters Made by Bangalore Torpedoes in Tests at Fort Knox, Ky.
Top: M1A1 Bangalore Torpedo Cartridges
Bottom: M1A2 Bangalore Torpedo Cartridges

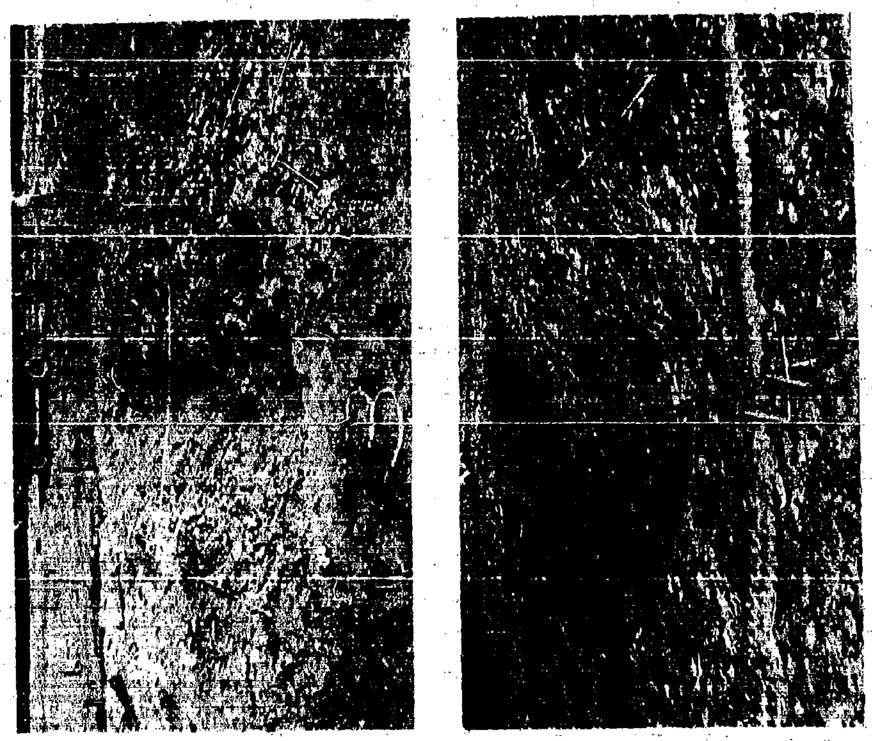


Fig 6 Craters Made by Demolition Snakes in Tests at Fort Knox, Ky.
Top: M3 Snake Demolition Cartridge
Bottom: M3A1 Snake Demolition Cartridge

the ability of filler 1 loaded in both the bangalore and snake to withstand the severe treatment of being pushed and dragged along secondary roads and cross-country terrain. Both items withstood the test without incident (Ref D).

DISCUSSION OF RESULTS

12. Main and End Charge Sensitivity: The principal reason for seeking a replacement for the crystalline TNT end charges in the M1A1 bangalore torpedo and M3 demolition snake is that TNT in granular form is highly sensitive to rifle bullet impact. During testing, a marked contrast was observed in the rifle bullet sensitivity of crystalline TNT and that of Composition A-3. TNT detonated 13 out of 45 shots with a .30 caliber ball and 34 out of 53 shots with a .50 caliber ball. Composition A-3 not only did not react to .30 caliber and .50 caliber ball but, in the limited number of tests conducted, was not detonated by .50 caliber APIT rounds. Bullet-sensitivity tests of cast TNT, 80/20 amatol, and Composition B as center or main charges showed that all of these explosives are essentially insensitive to impact by a .30 caliber or a .50 caliber ball.

13. Sensitivity to Initiation: Tests of the comparative sensitivities of crystalline TNT and Composition A-3 to initiation by No. 45 or No. 60 detonating cord were included, because it was believed that this was one of the required methods of initiation (Ref E). The cord was wound around one end of the torpedo. For some of the tests, the loose end was inserted into the detonator well. Neither the crystalline TNT nor the Composition A-3 was consistently initiated. It should be noted that instructions prescribing detonating cord for initiating torpedoes are indefinite in that the weight of the cord to be used is omitted. What is important is that the end charges were initiated unfailingly when a Type II special blasting cap was inserted in the detonator well. When the cap alone was used as the initiator, Composition A-3 functioned in all tests at ambient temperature, −40°F, and −65°F. There was never any question as to complete functioning.

14. Barbed Wire Clearance: Tests conducted at Picatinny Arsenal to determine the wire clearing capabilities of the various explosive combinations showed that filler 1-loaded torpedoes were slightly superior to the standard torpedo and to the filler 2-loaded items. Tests conducted at Fort Knox showed no appreciable difference in this respect between filler 1-loaded torpedoes and the standard torpedoes. Judging the total results conservatively, it may be concluded that units loaded with filler 1 are at least as effective in wire clearing as the standard units. It is understandable that the Picatinny Arsenal tests detected a difference in performance, whereas the field tests did not. The Picatinny Arsenal test structure was designed for the specific purpose of measuring performance quantitatively.

15. Both at Picatinny Arsenal and at Fort Knox, cratering tests showed that filler 1-loaded torpedoes produced appreciably wider and deeper craters than the standard type. At Picatinny Arsenal filler 2-loaded torpedoes were included in the cratering tests. These were found to be inferior to filler 1-loaded bangalores, but superior to the standard units. The cratering capability of the bangalore torpedo should be considered an important functioning characteristic because it represents the mine-clearing potential of the demolition item. In actual mine-clearing tests conducted at Fort Knox, filler 1-loadings proved considerably more effective than the standard loadings with both the torpedo and the snake.

16. The durability tests at Fort Knox showed that filler 1-loaded units can be safely handled. This was demonstrated by the fact that they withstood the joltings, vibrations, impact, and shock that were imparted to them by the special rough road treatment to which they were subjected.

17. It is known from laboratory tests that Composition B is more brisant than 80/20 amatol. This greater brisance is demonstrated by its superior mine-clearing and cratering effectiveness. It is also known that amatol is hygroscopic and may therefore be expected to function less reliably under certain conditions than the relatively non-hygroscopic Composition B. Composition A-3 is more brisant and less sensitive to rifle bullet fire than the granular TNT. In addition to its more obvious advantages, filler 1 has another desirable feature, namely, higher density. The snake cartridge with filler 1 weighs 50.6 pounds, whereas the standard-loaded cartridge weighs 40.6 pounds; the bangalore cartridge with filler 1 weighs 15.42 pounds, whereas the cartridge with the standard filler weighs 12.42 pounds. Obviously, the superior performance of filler 1 is due in a large measure to the greater weight of the explosive. It is also evident that this higher charge density makes it possible to improve the standard torpedo and snake in either of two ways:

a. Improved performance can be achieved by using the standard metal parts and accepting the greater loaded weight of filler 1.

b. Standard performance can be obtained by redesigning the metal parts so that the items, when loaded, would weigh the same as the present standard unit, but would be smaller.

18. Although Composition A-3 can be tamped into the torpedo or snake as the end charges without great difficulty, the simple pouring operation involved in the loading of granular TNT, is certainly easier. The loading procedure for the end charges can, however, be simplified by using Composition A-3, or probably some other appropriate explosive, such as PBX in pellet form.

19. In view of the superior performance

and rifle-bullet safety of filler 1-loaded torpedoes and snakes, the items loaded with this filler were released for production engineering studies. In accordance with Reference G, the torpedo and snake with filler 1 were designated: torpedo, bangalore, M1A2, and snake, demolition, M3A1, respectively.

EXPERIMENTAL PROCEDURE

20. The standard M1A1 bangalore torpedoes were loaded in accordance with the drawing shown in Figure 7. Torpedoes containing filler 1 were loaded as shown in Figure 8. Torpedoes containing filler 2 were loaded in accordance with the same drawing except that cast TNT was used in place of Composition B. In loading Composition A-3, a weighed portion was poured into the ends of the tube and consolidated by hand tamping with a wooden rod. The standard M3 demolition snakes were loaded in accordance with Figure 9. Snake cartridges containing filler 1 were loaded in accordance with Figure 10.

21. The bullet impact tests were performed by placing a single torpedo horizontally on a mound of earth. Target points were marked 2 inches and 15 inches from each end of the cartridge. The effect of the firing on the explosive was observed and recorded. Complete destruction of the torpedo was reported as "detonation" and the appearance of smoke was reported simply as "smoke."

22. The test to determine whether detonating cord could be used to initiate torpedoes was performed by attaching the cord within 2 inches of the end of the torpedo using a four-loop clove hitch. A blasting cap was then fastened to one free end of the cord and detonated. In a modification of this test, the same procedure was used except that one end of the cord was first placed in the detonator well.

23. In all initiation tests except those conducted with detonating cord, a Type II special blasting cap was inserted in the detonator well of the torpedo and initiated with a ten-cap blasting machine.

24. For the barbed wire cutting test conducted at Picatinny Arsenal, a frame 30 feet long by 20 feet wide was constructed of 1½-inch pipe. No. 12 gage double-strand barbed wire was strung 2 feet apart and hand tightened. Four tiers 1½ feet apart with 11 strands on each tier were arranged. The torpedoes were placed on dry, rocky ground, 3 feet below the first tier and perpendicular to the direction of the barbed wire (Fig 1). All units were fired at ambient temperature.

25. Durability tests on the torpedo cartridges were performed at Fort Knox by towing a train of several lengths, butted end to end, over cross-country terrain. The durability of the M3 demolition snake was tested with a 175-foot length of the snake. Fifty feet of the cartridges, loaded with filler 1, were placed in the middle. The test consisted of towing and pushing the units 3 miles over cross-country terrain.

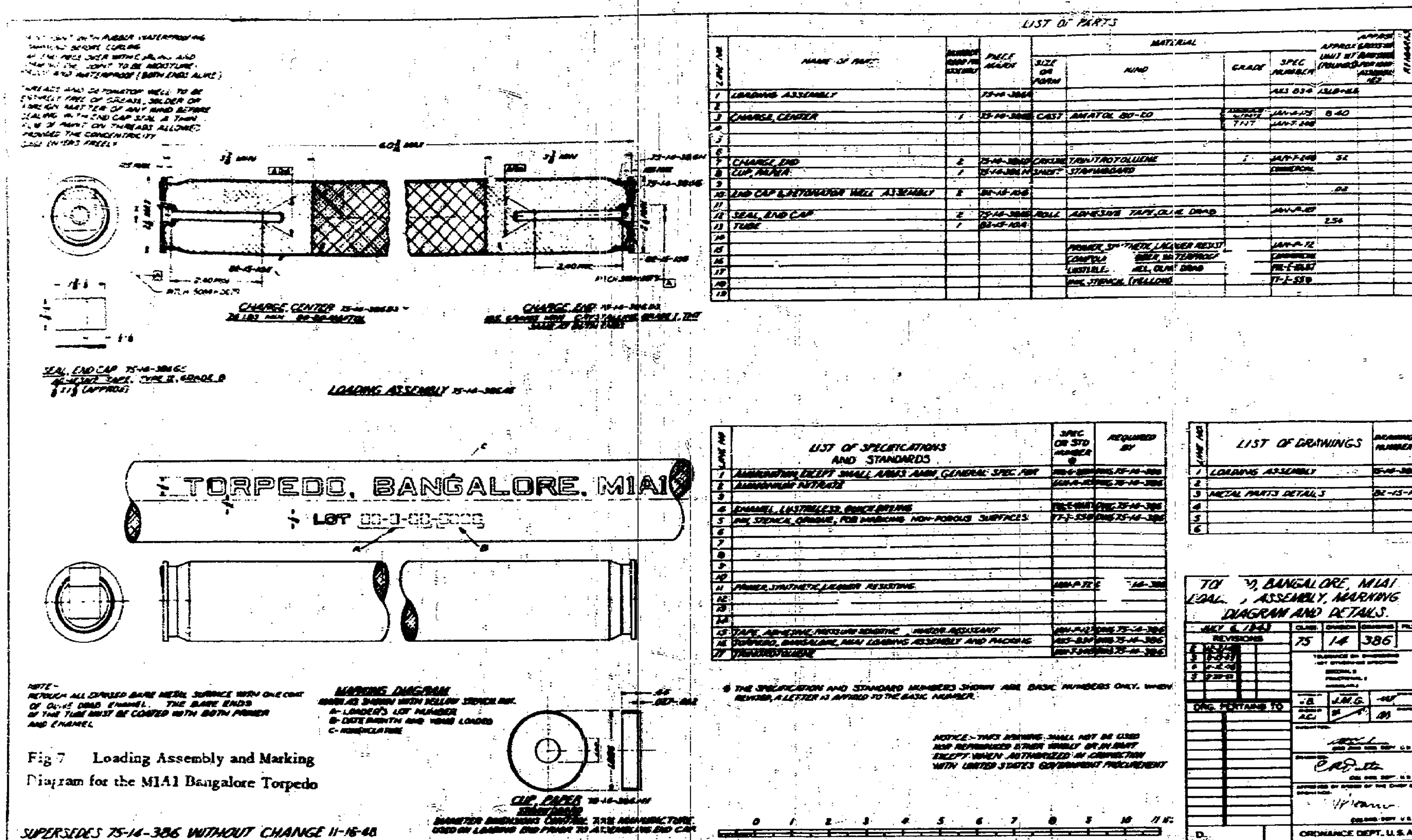


Fig. 7 Loading Assembly and Working Diagram for the M1A1 Bangalore Torpedo

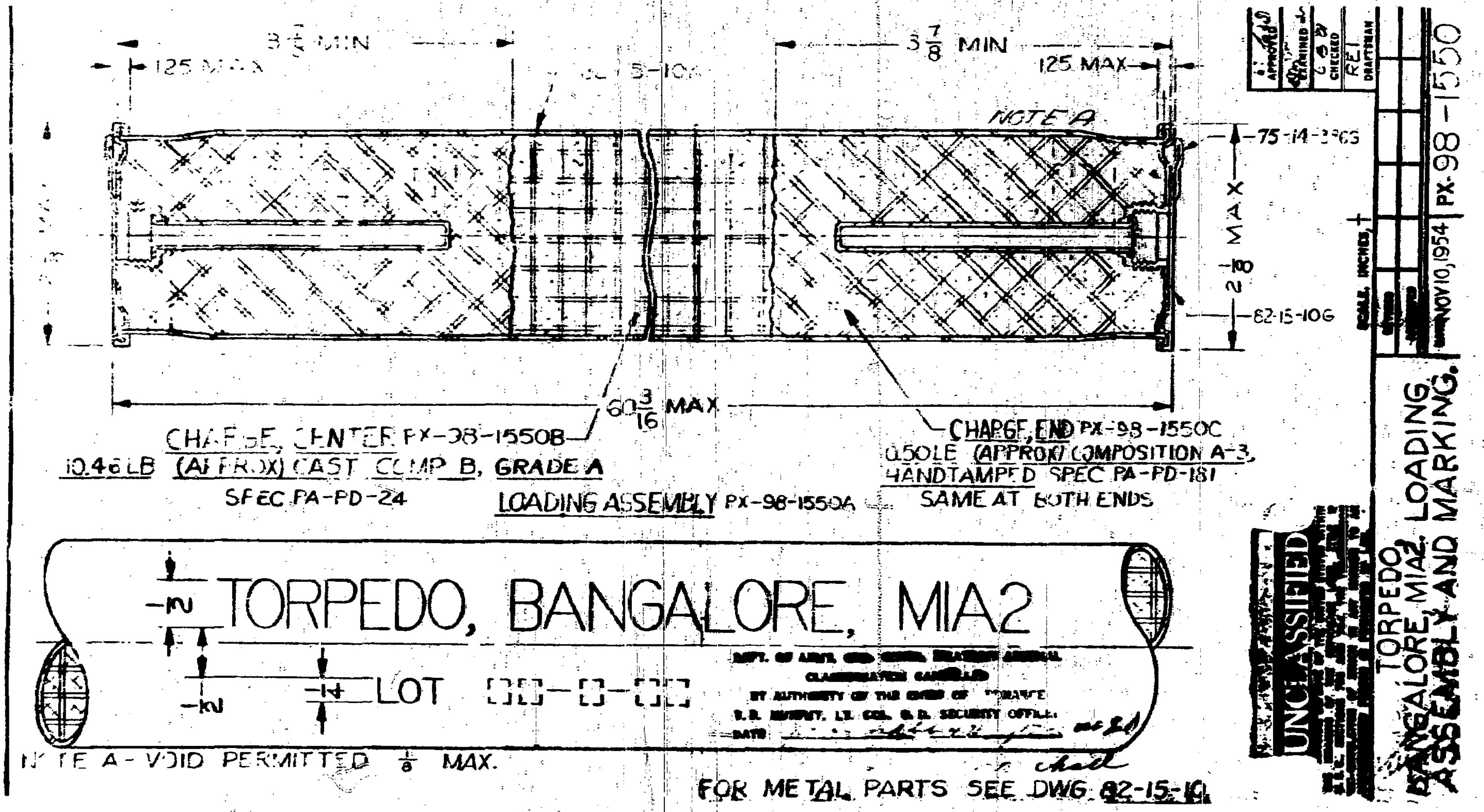


Fig. 8 Loading Assembly and Marking for M1A2 Bangalore Torpedo

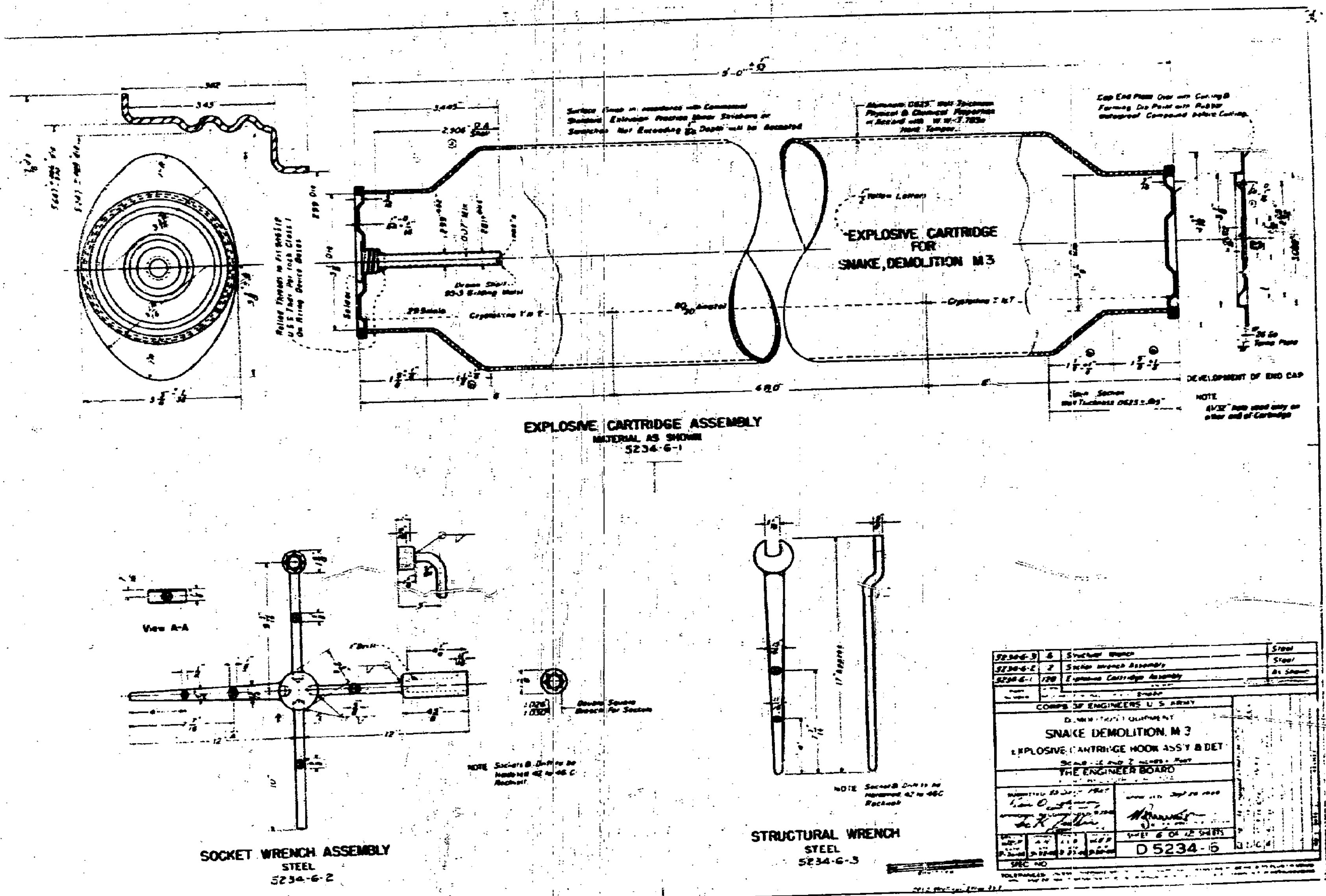
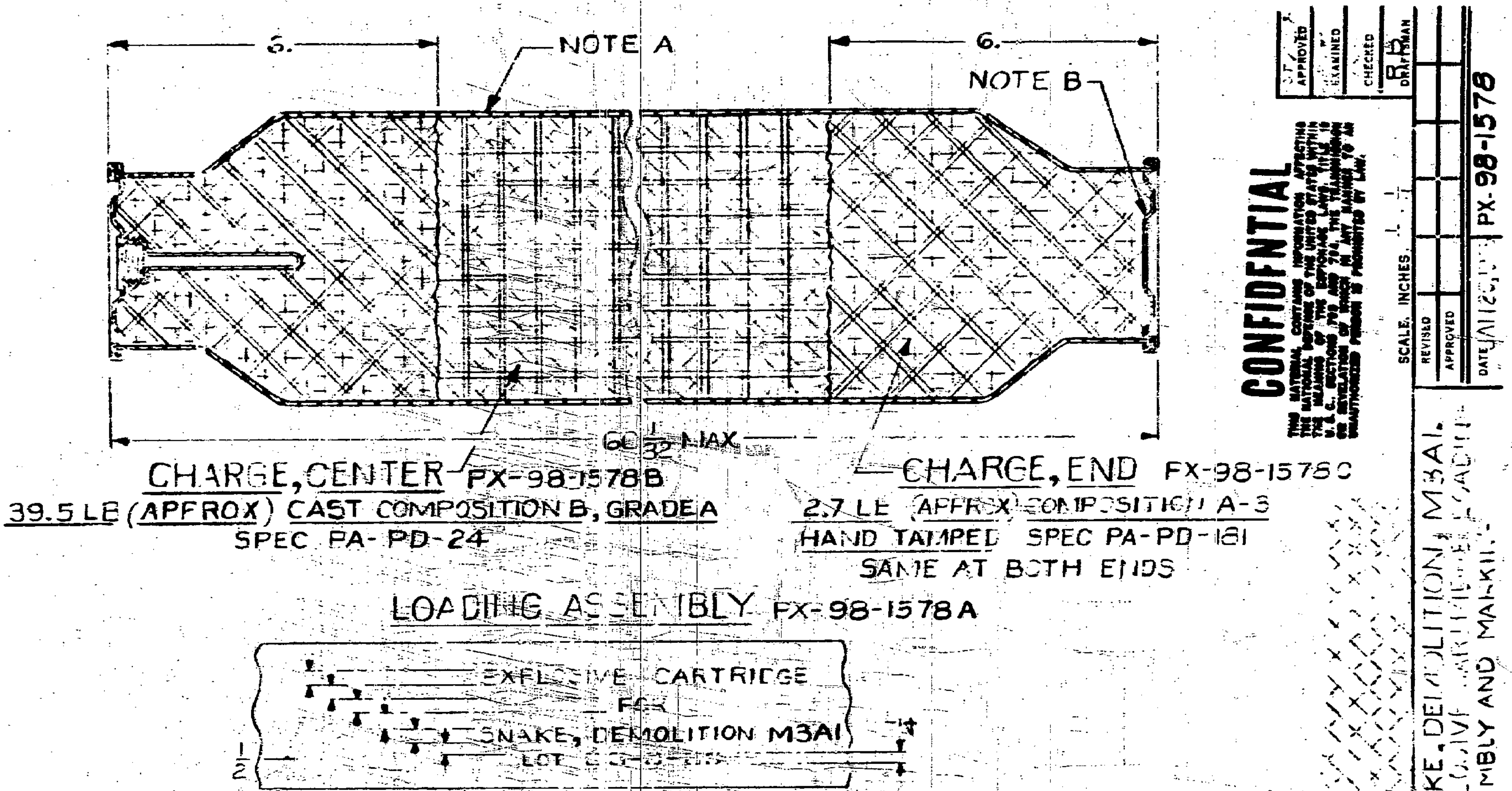


Fig 9 M3 Demolition Snake



B

A—Reference Drawings for Explosive Cartridge Assy
Corps of Engr Dwg D-5231-6, Pc Mk 5234-6-1
B—Void Permitted ⅛ Max

Fig. 10 Explosive Cartridge, Loading Assembly, and Marking for M3A1 Demolition Snake

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TABLE 1

Results of Rifle-Bullet Impact-Sensitivity Tests of Bangalore Torpedoes

Type of Round	Temperature	Main Charge			Booster Charge	
		Cast TNT	Comp. B	80/20 amatol	Comp. A-3	Crystalline TNT
.30-cal. ball	Ambient	10 NA	22 NA	22 NA	55 NA	32 NA 13 Det
.50-cal. ball	Ambient	10 NA	22 NA	22 NA	54 NA	16 NA 27 Det
.50-cal. AP	Ambient				6 NA	
.50-cal. APIT	Ambient				6 NA	
.50-cal ball	−65°F	3 S 3 NA	6 NA	3 S 3 NA	12 NA	2 NA 2 Det
	160°F	10 NA	10 NA	10 NA	20 NA	5 Det 1 S

NA = No Action; Det = Detonation; S = Smoke

TABLE 2

Effect of Temperature and Method of Initiation on Functioning Characteristics of Bangalore Torpedoes

Type of Booster	Temperature	No. 45 Detonating Card 4-loop clove hitch		No. 60 Detonating Cord 4-loop clove hitch with loose end inserted in well hole		No. 60 Detonating Cord 4-loop clove hitch		Type II Special blasting cap	
		Det.	No action	Det	No action	Det	No action	Det	No action
composition A-3	Ambient	0	3	0	0	2	8	12	0
crystalline TNT		0	3	0	0	2	3	7	0
composition A-3	–65°F	0	0	3	4	1	6	2	0
crystalline TNT		0	0	0	0	2	0	0	0
composition A-3	–40°F	0	0	0	0	0	0	10	0

TABLE 3

Picatinny Arsenal Barbed Wire Clearance and Cratering Tests

Type of Loading	No. of tests	Tier no.	Double-St and 12-GA. Barbed Wire	CRATER SIZE (Approx. Values) Length, ft.	Width, ft.	Depth, in.	Volume, cu. ft.
80/20 amatol crystalline TNT	5	1	17				
		2	17				
		3	15				
		4	16	6	3	8	12
			65				
Cast TNT composition A-3	5	1	17				
		2	17				
		3	16				
		4	18	6	4	8	16
			68				
composition B composition A-3	5	1	18				
		2	20				
		3	17				
		4	18	6	4	12	24
			73				

TABLE 4

Clearance of AP and AT Mines by Bangalore Torpedo and by Demolition Snake

Bangalore Torpedo

Total Path Width, ft	% Cleared in Dry Soil		% Cleared in Wet Soil	
	Standard Filler	Filler 1	Standard Filler	Filler 1
4	100.0	100.0	100.0	100.0
5	87.5	87.5	56.3	93.5
6	87.5	87.5	61.0	82.2
8	75.0	90.0	58.0	85.7
10	67.9	78.6	53.5	74.0
12	59.5	78.2	55.2	76.6
14	59.5	78.2	53.2	72.8
16	47.5	71.5	44.0	65.9

Demolition Snake

Total Path Width, ft	% Cleared in Dry Soil		% Cleared in Wet Soil	
	Standard Filler	Filler 1	Standard Filler	Filler 1
10	83.5	100.0	100.0	100.0
15	94.5	100.0	84.5	100.0
20	95.5	100.0	88.0	100.0
25	96.5	100.0	84.0	100.0
30	94.0	100.0	87.5	94.0
35	94.5	100.0	85.0	94.5
40	95.0	100.0	87.0	95.0
45	93.5	100.0	82.5	95.5
50	90.0	100.0	79.0	96.0
55	87.5	100.0	73.0	96.5
60	85.0	97.0	74.5	90.5
65	85.0	94.0	71.0	91.0
70	81.5	90.5	100.0	83.5
75	76.5	88.5	100.0	100.0
80	74.0	86.5	100.0	100.0

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